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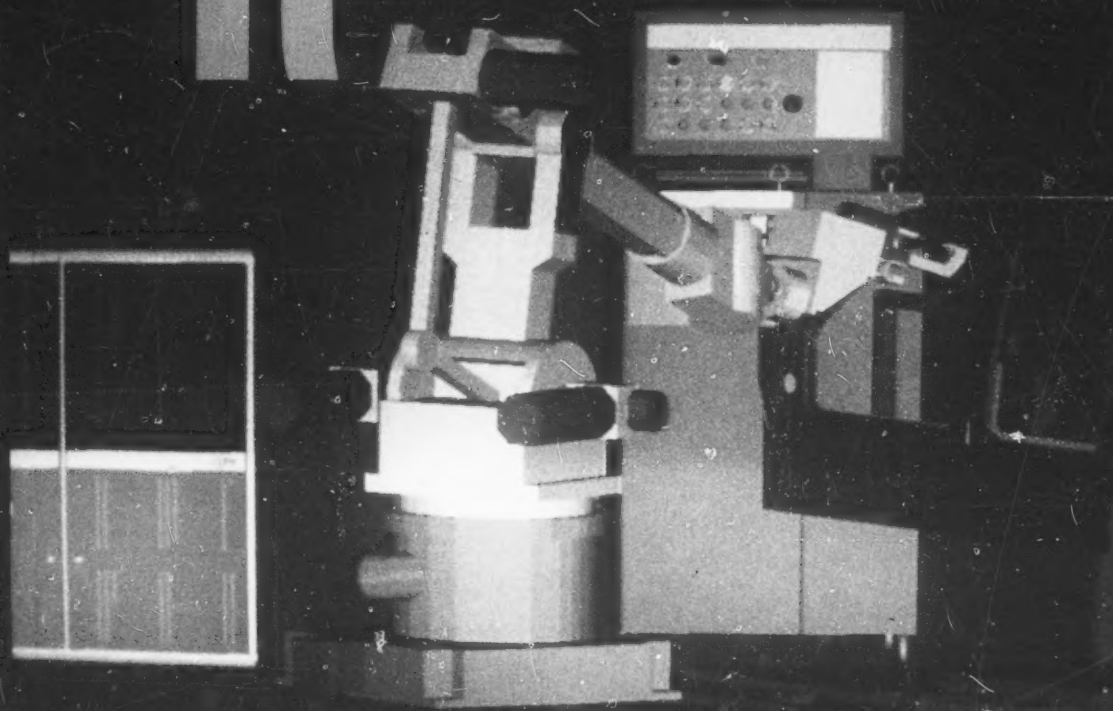
IRON AGE APRIL 18, 1986

MANUFACTURING MANAGEMENT

ROBOTICS EXTENDS ITS REACH IN THE FACTORY



IS U.S. MANUFACTURING
TING ITS KNOW-HOW?

THE BLUEPRINT
FOR MAZDA'S U.S. ASSEMBLY PLANT

APRIL 18, 1986 VOL. 229, NO. 8

IRON AGE
MANUFACTURING MANAGEMENT

Editorial 7
Patience is no small virtue.

Newswatch 11
House leaders are pushing for a trade reform law by mid-May.

You and Your Job 20
The eyes have it... when you're talking VDTs.

Management Know-How 21
Is U.S. manufacturing exporting its expertise?

Mazda 28
Is Hofu the blueprint for its U.S. assembly plant.

Robots 33
Robotics extends its reach in the factory.

Cressona 41
Aluminum extruder concentrates its focus to stay ahead.

Signode 47
The Midwest company is pursuing new products and businesses.

Westec 50
Industry is crying out for help.

ASEA Press 52
Aircraft technology is helping European automakers.

Technically Speaking 54
Forging and testing cells working at Pratt & Whitney.

Materials Report 61
Is increased demand the real reason for the gain in steel orders?

Price Trends 68
Now, the question is, where's the bottom?

Next Issue: Steel's Leapfrog Technologies.

Departments

EDITORIAL STAFF 8
LETTERS 8
PRODUCT & EQUIPMENT REVIEW 55
FREE LITERATURE 57
AD INDEX 58
BUSINESS STAFF 58
MANAGEMENT SERVICE CARD 59
P&P DATA 3/31 64
FERROUS SCRAP 3/31 65
CLEARING HOUSE 66

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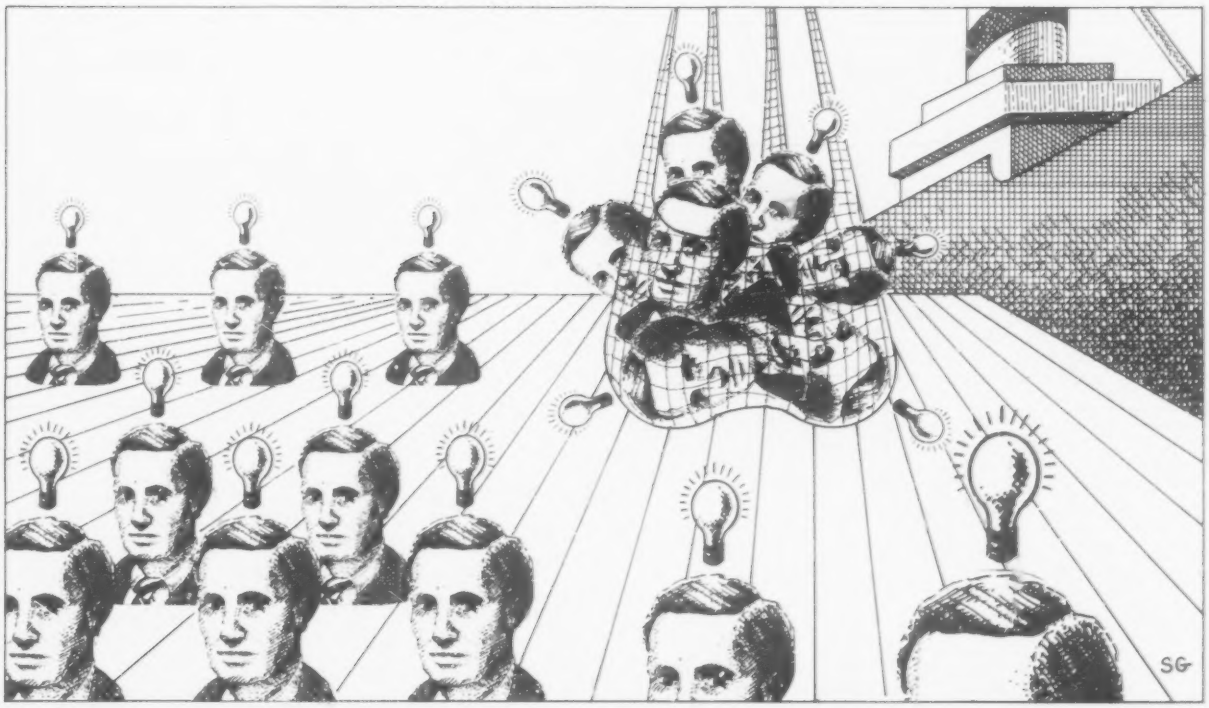


MANUFACTURERS RISK LOSS OF KNOW-HOW

Many manufacturers are trimming output. Others are importing heavily. And some have foreign joint venture partners making goods for them. Is loss of manufacturing know-how a real danger?

BY JOHN D. BAXTER

A growing number of trend-spotters these days are hailing a "watershed change" in U.S. manufacturing. A label sometimes put on this change is "de-manufacturing."

The term relates to the growing number of U.S. manufacturers that are having others make their products for them, are diversifying into non-manufacturing lines, or are giving up on manufacturing.

Usually, the "others" making products for U.S. manufacturers are foreign producers—either import sources or joint venture partners. In many other cases, U.S. manufacturers buy foreign-made products and act as distributors for them.

Notably, many leading U.S. basic goods manufacturers are in the forefront of the movement.

This sweeping trend is causing concern among some U.S. business leaders and economists. The products farmed out, or purchased, are often high value-added ones that entail high degrees of production know-how.

Concern centers on the question of whether the growing trend points to a serious loss of know-how in manufacturing technology by U.S. producers.

Harvard economist Robert B. Reich, in a recent article, flatly stated that the proliferating joint ventures of U.S. manufacturers with Japanese producers, "give away our future." The "giveaway," as he sees it, is in the loss of manufacturing knowledge and experience.

Another analyst sees a new type of company emerging—"one that may design and distribute but doesn't actually make anything."

Five Paths

The pull away from manufacturing by U.S. companies follows five general patterns.

For one, there are manufacturers that have aggressive attitudes and policies of a make-or-buy nature. In these companies, when competitive cost analysis points to a "buy" action, that is what is done. One management consultant has noted that about 70 pct of all the make-or-buy analyses of which he is aware "gave the green light to "buy" decisions."

A second approach to limiting

manufacturing involvement is a joint venture arrangement between two manufacturers. It seems the most common of these arrangements is between U.S. and Japanese companies. Also, the production involving the higher value-added items usually is left to the Japanese partner. This is true in the auto industry where General Motors, Ford and Chrysler all have joint ventures with Japanese auto firms. All plant design and product engineering has been left to the Japanese partners.

A third approach in manufacturing realignment in this country is where companies cease, or lessen, domestic production and set up foreign plants. This can have a chain reaction as U.S. supplier manufacturers often follow their customers overseas. Case in point: Parker Hannifin Corp., a leading maker of fluid power products. Explained company executives recently, "Many of our customers are moving product manufacturing to lower-cost plants and requiring that we support them with locally-manufactured products." This was noted as the company recently announced plans to set up Asian operations. The company is already supplying U.S. manufacturers from its operations in Europe.

A fourth approach U.S. producers are taking to cope with slipping markets or competitive pressures is to diversify into other lines of business, often non-manufacturing lines. A good example of this is seen in U.S. Steel Corp.'s diversifying into oil. Steel products now account for less than one-third of the annual revenues of the corporation.

A fifth approach used to escape a manufacturing burden is for a company to pull out of manufacturing altogether. Ogden Corp., formerly in lines like shipbuilding, machine tools and metals processing, is now totally a services company—by management design and intent.

When It Started

Some quick history is in order to bring all the de-manufacturing forces together and put a starting time on them.

A consensus puts the start of the so-called de-manufacturing trend in the years 1979-80. Those years, and those immediately following, turned out to be all-hell-broke-loose years for U.S. manufacturing.

First, U.S. economic growth flopped badly from early 1979 through 1982. It was not a matter of slowed growth; there was actual negative growth of 5 pct over that period. For any practical meaning, 1980-82 was a three-year recession period. There were two recessions in the time span with slow growth all around them.

In those years of economic contraction, the prime interest rate averaged more than 16 pct. Manufacturers in mature industries (where most de-manufacturing is now occurring) were staggered. Those industries were, and are, ones with relatively slow growth rates. Too, they are capital-intensive industries. Record high credit costs hit them with a special fury.

On top of that, the U.S. dollar began its sickening spiral. The take-off year was 1981 when the dollar's exchange value with leading world trade competitors jumped by 15 pct.

Little wonder then that the U.S. trade balance in manufactured goods went from a $19 billion *surplus* in 1[illegible] to a steady collapse over subsequent years to a $101 billion *deficit* in 1985.

The effect of all these developments was that U.S. manufacturing—again, chiefly basic goods producers—were driven to the wall. In a disinflating economy, they couldn't get relief through price tag boosts on their products. The world was already under-pricing them. They had to retrench, cut costs. But many couldn't cut costs fast enough or deep enough.

So, they joined with others to gain strength, they diversified out of hard-hit lines and some even started on the path to exiting manufacturing altogether.

There are, as noted, scary implications for the economy in the pull away by so many companies from manufacturing—especially, the high value-added areas of manufacturing. If, in the U.S. economy, there is a serious loss in manufacturing technology know-how, this could affect living standards and national security.

Some analysts have noted that this country has already lost much of its know-how in making consumer electronic products.

"There are four production sectors of the economy where most wealth is created," noted Lee Hamilton, senior vice president of the National Association of Manufacturers (NAM). "Those sectors are agriculture, forestry and fisheries, mining and, of course, manufacturing. Those sectors create wealth because they take raw materials and other goods and add value to them.

"By comparison, those in the service industries are in fact serving the production industries. There would be no need, in a great many cases, for service industries if the production industries were not adding value to products. And that's why, even with the great employment growth in services, manufacturing is really the force that drives the economy."

Abstract talk about the wealth-creation aspect of manufacturing is one thing. But the illustrated table (see p. 23) showing what 100 new manufacturing jobs mean to a community makes the point clear. The data is from a 1984 study made by the U.S. Chamber of Commerce.

In the illustration, it is seen that 100 manufacturing jobs create 64 nonmanufacturing jobs and raise aggregate personal income by about $2 million. The second part of the table shows clearly how manufacturing supports various service industries.

In the study, the Chamber concluded: "In terms of net gains, the counties that experienced significant growth in manufacturing jobs were more prosperous, with increases in the number of businesses, retail sales and population, than the counties without significant growth in manufacturing."

The Big Question

Is manufacturing really letting go of its know-how?

What 100 New Manufacturing Jobs Mean to a Community*

Aggregate personal income	$1,948,353
New retail establishments	7
Nonmanufacturing jobs	64
Population increase	202
Family units	102
School enrollment	61
Retail sales	$1,477,453

*Figures represent a net change from 1970 to 1980. Source: 1984 Study of the U.S. Chamber of Commerce, based on census data from 1970 and 1980.

Employment Changes Resulting from 100 Workers Added to Manufacturing Sector of a Community

Source: U.S. Chamber of Commerce

Or, is U.S. manufacturing meeting a challenge and actually strengthening itself—and the economy?

The argument centers on the high value-added content of manufactured goods that are being lost by U.S. producers. These are products that involve the most know-how.

The hard fact is that there are no precise numbers on the extent of de-manufacturing that has occurred. That is, no one knows for sure just how many companies have been involved, and no one knows just how much manufacturing know-how, if any, has already been lost.

Probably, the best measure of whether or not U.S. producers have so far held their own is seen in data on value added by U.S. manufacturers as a percentage of the overall economy.

The table with this article (see p. 27) shows that value added by U.S. manufacturers has indeed held its own. For example, it was earlier noted that the starting point of the so-called U.S. de-manufacturing trend was 1979-80.

Significantly, the average annual value-added figure since that time has shown no decline (23.8 pct in 1980; 23.9 pct in 1985).

So, after five years of a supposedly strong trend movement to de-manufacturing in this country—and the farming out of much value-added work—the actual value added by U.S. producers held rock-firm as a share of the overall economy.

It seems that most economists readily concede that U.S. manufacturing is undergoing great change. But not all see that change as seriously cutting down value-added content, or leading to serious loss of know-how by American manufacturers.

The Dollar's Role

"We are in a period of change in manufacturing in this country," said F. Gerard Adams, professor of economics and finance at the University of Pennsylvania's Wharton School. "There is no doubt about that.

"But the change is chiefly away

(Continued on p. 27)

from production of mass-produced commodity-type goods into high-quality, trademark goods. These latter goods are of higher value-added."

In other words, Dr. Adams does not think that production of high value-added goods, or, manufacturing know-how is endangered. The changes that are occurring in manufacturing do not pose a long-term threat to those key elements.

"I think that as time goes on," he added, "you will see U.S. producers doing more as the Japanese are doing—sticking to high value-added manufacturing. The mass-produced commodity goods will be produced mostly by the Koreans, Mexicans, Brazilians and so on. They can produce these goods as well as we can. And, remember, we have long been good at high value-added production; we currently lead the world in such lines as computers and aircraft."

The Wharton economist also feels that a great deal of so-called de-manufacturing will end when the value of the dollar rachets lower. The strong dollar, more than anything else, he feels, has accounted for the bulk of the outsourcing, high imports and joint ventures that have been seen in U.S. manufacturing.

"A lot of the farming out of manufacturing that looked good when the yen was 240 to the dollar," he noted, "won't look nearly so good when the yen goes to 150 to the dollar, or quite possibly, to 120 to the dollar. There will be sharp adjustments made; it will take some time because many already-committed production agreements cover somewhat long periods of time."

Another View

There is still another point of view that says that de-manufacturing is not the main show in change that is taking place in U.S. manufacturing. This view holds that a shift in size and structure of manufacturing is what is happening.

This latter view was described, and even endorsed, by President Reagan in a major talk a year ago. "We have lived through the age of big industry," he said, "and the age of the giant corporation, but I believe that this is the age of the entrepreneur, the age of the individual."

Manufacturing Share of U.S. Economy — Value Added by Mfg. as Pct Share of Real GNP

1960	23.3%
1965	25.5
1970	24.1
1975	23.5
1980	23.8
1985	23.9

Source: U.S. Commerce Dept.

The President added that it was from this smaller-scale entrepreneurial sector where "American prosperity is coming from now."

One top management consultant estimates that of the 40 million jobs added in the U.S. economy in the past 15 years, some 33-35 million were created by entrepreneurial operations. This took place as many large corporations were retrenching or pulling out of manufacturing.

Futurist John Naisbitt has said, "America's traditional bigger-is-better manufacturing philosophy is giving way to 'focused factories' that result in high productivity and improved labor relations."

Trade Weighted Value of Dollar Index vis-a-vis Currencies of 15 Major Countries

1985	Feb.	137.9
	April	131.9
	June.	129.4
	Aug.	124.6
	Oct.	117.2
	Dec.	114.8
1986	Jan.	113.7
	Oct.	111.5

Source: Morgan Stanley & Co.

Mr. Naisbitt noted that General Electric and a number of other industrial giants are now replacing huge manufacturing complexes with new, smaller plants—the focused factories. He cited as an example of focused factories, the mini-mills that held only 2.5 pct of the U.S. steel market in 1964 and now claim 20 pct of the market.

Too, while big-dollar corporate mergers have captured headlines, many more companies have been peeling off divisions and subsidiaries in an effort to become smaller, more manageable and stronger corporate entities.

Record numbers of corporate divestitures have been taking place. The merger broker firm, W. T. Grimm Co., reported 953 divestitures took place through the first three quarters of 1985—a number greater than for all of 1984.

Certainly, many manufacturers that make mass-production goods, have been trimming back operations. Producers of a variety of commodities and basic goods have trimmed operations and reduced or redeployed assets. That has been a visible restructuring that has been going on in the economy; it does not mean manufacturing know-how is being lost.

In short, at this time, it cannot be shown irrefutably that all U.S. industry is caught up in a massive de-manufacturing movement.

More likely, most recent actions by U.S. manufacturers have been designed either to cope with the passing effects of a highly over-valued dollar or strengthen themselves for the long run.

The shifting of production—from commodity-type to high value-added products—is going on. Focused factories are an example of a move towards a more productive and more competitive U.S. manufacturing sector. In addition, the great entrepreneurial surge taking place in this country belies any weaknesses among U.S. businessmen or the business process. □

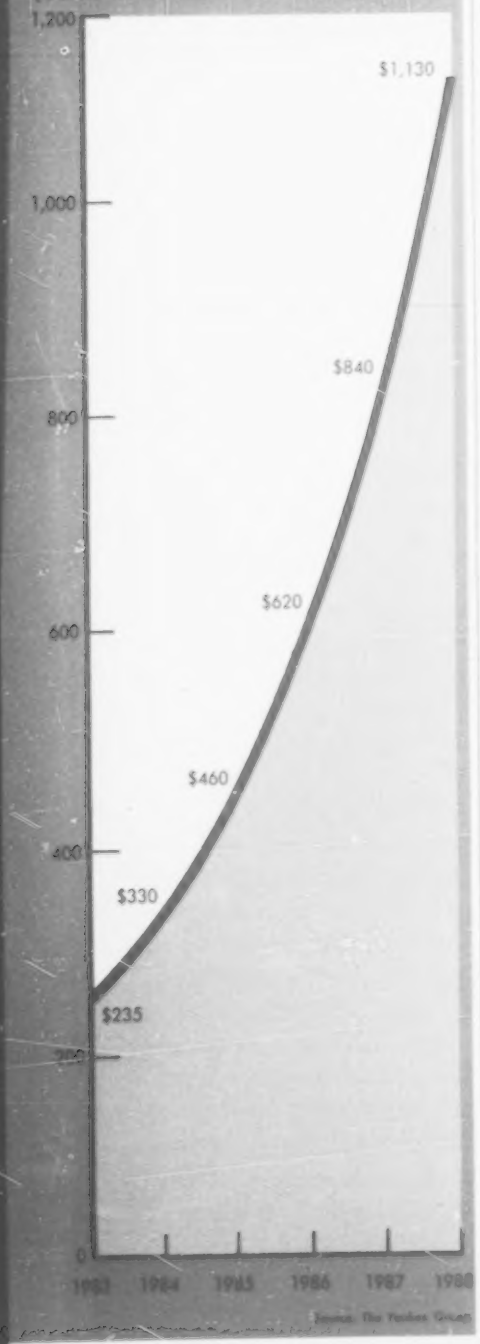
ROBOTICS EXTENDS ITS REACH IN THE FACTORY

BY ROBERT E. HARVEY

While orchestrating robot development, robot builders often play variations on a central theme. Each year that theme changes.

In 1983 the echoing refrain was 'practicality.' That year at Robots 7 (a show sponsored by SME's Robotics International and the Robotic Industries Assn.) no-nonsense robots strained at real factory tasks. Earlier shows had robots rolling dice and playing tic-tac-toe. (Cont. on p. 36.)

The Robotics Market Continues Its Upward Pace
(Sales in Millions of Dollars)



Vendors the next year at Robots 8 continued singing the praises of usefulness but began to voice the need for robots to harmonize with other devices. When working in concert, the general purpose robot with the ability to perform a variety of roles became the recognized star.

By Robots 9, the general purpose robot had become a has-been. The rising star was the specialist: the assembly robot, the clean room robot, the arc welding robot, and the sealing robot, to name a few.

This year, when Robots 10 opens its doors April 21-24 in Chicago, the specialist will again be featured, but no longer in a staring role. Devices operating in concert will be highlighted, only this time the featured performer will not be a robot but a choir of specialized machines working in harmony.

Integrating robotic applications is not only the theme for Robots 10, it is also the central strategy of an increasing number of robot manufacturers. Many believe that the future belongs to those firms with the ability to supply complete manufacturing systems, not just robots. To better reflect their expanded role as systems integrators and suppliers, several firms, including GMF Robotics, considered updating their name. One firm, American Robot, is dropping "Robot" from its title.

"Our recent transition from being a robot manufacturer only to become a leading manufacturer of a wide range of computer-integrated manufacturing (CIM) and flexible automation products has led to a new name for our company: American Cimplex Corp.," said Romesh Wadhwani, its chairman and CEO.

Paul Ockerman, president of Unimation, Inc., sees the need to widen his company's focus as well. "The future of Unimation depends on our continued ability to differentiate ourselves from the competition. We have done this in the past with our hardware and will do it in the future with our control technology and the ability to integrate our robots with sensors and other automation equipment as we move toward the factory of the future."

Three years ago, Unimation became part of Westinghouse. Currently, Unimation is part of Westinghouse's Advanced Production Technology Business Unit. Being part of this unit, which does systems and applications engineering, gives Unimation an entree into major systems business and technology.

Several developments have spurred this urge to shed the constraints of the basic robotics business and brave the perils of the integration and systems business. Most critically, the demand for the simple stand-alone robot is drying up. Jobs once needing this robot now require more complex equipment or fewer new robots.

"I think that the early simple applications are becoming saturated," said Richard H. Johnson, manager of product and market planning, GMF Robotics Corp, Troy, Mich. "The reason all applications have not yet become saturated is that some have higher barriers to entry."

At General Motors, for instance, applying sealant to automotive parts was a labor-intensive task. But robots could not be used until vision systems came along with three-dimensional offset capabilities, allowing them to apply sealant accurately.

"Three-dimensional vision is necessary because a car is simply not positioned accurately enough to permit automated sealing without 3-D vision," explained Mr. Johnson.

Automatic spot welding is an example of a task that once could be done by a simple robot but is now demanding a sophisticated system. "Rather than just moving the gun to the spot to be welded, the robotic system now is controlling the spot weld guns directly. It is monitoring every weld, and eventually the path (for) the gun will be passed to the robot from an off-line system," said Mr. Johnson.

Experience Curve

Their rising experience curve has paved the way for more robot vendors to move into systems development. Robot vendors over the past decade have learned well how to use robots effectively in manufacturing

operations. This has not always been the case. Installed robots in the early years were difficult to use, difficult to integrate with other operations, difficult to communicate with, and difficult to program. The robots (the robot arms and grippers) haven't changed radically over the years. What has changed is the experience of robot manufacturers.

"The robot that Prab built in 1976 is much like the one being built in 1986," said Walter Weisel, president of Prab Robots Inc., Kalamazoo, Mich. "It is just that we have learned how to apply it to manufacturing operations."

Its diverse application experience has taught Prab that becoming a systems supplier—not just a robot supplier—was the wave of the future.

"At this point, there is a good case to be made that Prab is the leading robotics system supplier in the country. Most others woke up last year to the fact that they ought to get heavily into systems," said Mr. Weisel. "We woke to that fact in 1982 when we got shocked into the realization that GM was going into the robotic business, as was GE and Westinghouse."

A final development propelling the robot vendor into the systems business has been the growth of new technology, principally computer technology. Because robots are flexible creatures, they can be wedded to a variety of technologies. They are working with lasers and water jet cutters to do various metal cutting and metal processing jobs. Linked to vision systems, they can react to changes on the factory floor. Also, robots are being merged with machine tools and material handling equipment, as well as cell controllers, networks, and CAD/CAM equipment.

This evolution from a stand-alone robot to a robotic system went through three stages, said Mr. Johnson of GMF. "You might say that we started with task-oriented robots, are now using local cell-oriented robots, and are headed toward total-cell-oriented robots."

Robots started out doing three basic tasks: spot welding, painting, and picking and placing. To do these tasks, the robot was jogged into position with a teach pendant. Once taught, the robot would repeat the path in a continuous cycle.

"At this basic level, the robot was mainly a tool to position an end effector," said Mr. Johnson. "The controller of a task-oriented robot evolved from the NC controller and it was primarily position-oriented."

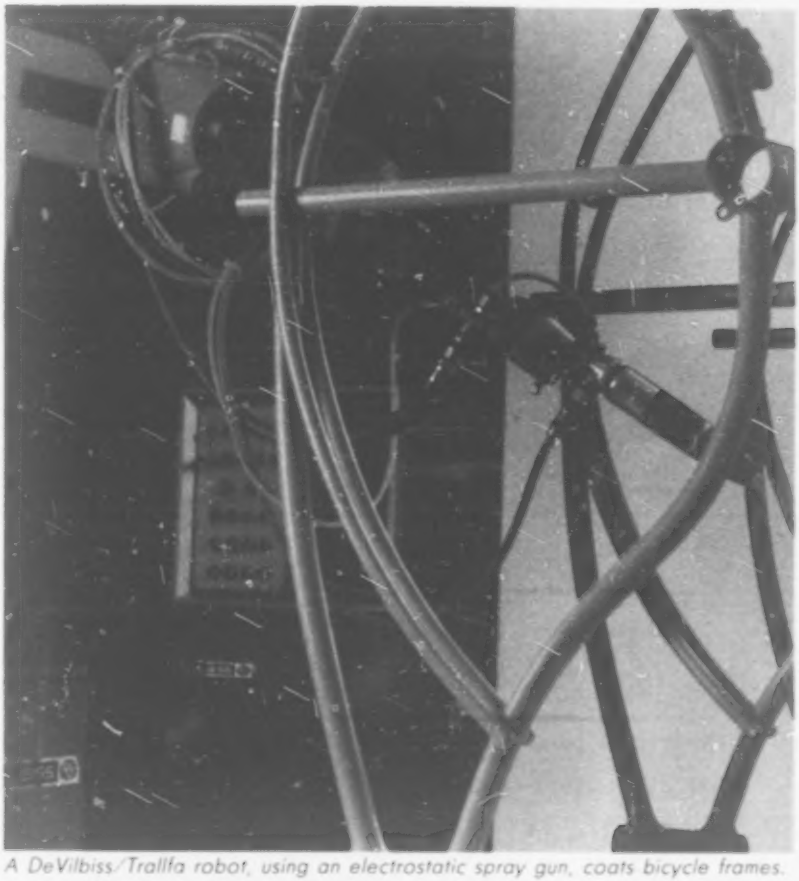
At stage two of its evolution (local cell orientation), the robot still is jogged into position with a teach pendant. Now though, the robot controls not only the positioning of the end effector but the process as well. In some spot welding applications, the robot positions the spot weld gun and controls its operation.

To do a variety of tasks, a robot needs more than a position-oriented control language. Higher level languages were developed that permitted such activities as multi-tasking (the ability to perform two tasks simultaneously).

"If you think of a language, it is based on two things—position data and logic. Higher level languages were needed to move the robot toward becoming a logic-oriented machine," said Mr. Johnson.

Today, robot manufacturers are moving from stage two toward stage three in this evolution. This stage is oriented toward total cell control. "At this level," explained Mr. Johnson, "vision becomes important as an option for the robot, as does the ability to teach (robot) path information directly from an off-line programming link to the user's database. That means you no longer have to use a teach pendant, for you are directly down-loading data from the user database."

With robots now involved in the total operation of manufacturing cells and systems, robot manufactur-



A DeVilbiss/Trallfa robot, using an electrostatic spray gun, coats bicycle frames.

ers are spreading their focus beyond the individual robot to other elements that go into a flexible system.

As an example, vision systems and tactile sensing allow a robot to interact more effectively with its local environment. Robot manufacturers are using CAD/CAM systems off-line to program robots. Robots are being integrated with material handling equipment. GMF, for example, will soon be in the automated guided vehicle business.

New Languages

New computer languages are key to the movement of robots into systems. Several useful high-level robot languages exist today and provide ease of use, off-line programming and cell integration capabilities.

Unimation recently introduced its new high-level language: Val III. Val III is multi-tasking and has expanded mathematical functions for such tasks as the manipulation of transforms, vectors, and strings. It is an English-based language which eases a programmer's task.

While languages like Val III are improvements over past robot languages, the lack of a standardized language remains a major barrier to computer-integrated manufacturing (CIM). Each robot maker has its way of programming robots. Trying to get different robots to work together is a nightmare.

It is a little early yet to predict a winner, but one language nearer than others to becoming a factory standard is Karel from GMF. Karel has the inside track because companies outside of GMF are adopting it. Allen-Bradley, a large manufacturer of robot controllers, recently announced its commitment to Karel.

Allen-Bradley had been designing its next generation of robot controllers and considered inventing its own language. "We decided that what the world did not need was another robot language," said Jay Jeffery, engineering product manager in charge of the robot products at Allen-Bradley. "After considerable analysis we went with Karel."

GMF Robotics has incorporated a vision system into this arc welding robot.

Allen-Bradley went with Karel for a variety of reasons. For one, it was acceptable from a functional and performance standpoint. For another, it seemed like the best bet to evolve into a standard. It also helped that GMF was the largest robot supplier around and tightly connected to the auto industry, a major market for Allen-Bradley.

What swayed Allen-Bradley the most was GMF's decision to promote Karel as an open language. Past languages developed by robot manufacturers were proprietary, closed to enhancement by others.

Being able to buy robots from various vendors and program them with the same language will ease the robot user's job considerably.

A strong alternative to Karel is AML from IBM, which also bills itself as a general purpose language for plant floor automation. "Recent AML efforts are exploring portability, compilability, opening the system, providing linkages to other languages, and controlling a variety of robots and devices other than robots," said an IBM spokesman.

With a high level language, off-line programming, the ability to develop a program and transfer that program to a robot instantly, becomes a possibility.

Typically, teaching the robot a new program requires taking the robot out of production. If changes must be made to the workcell, then the robot must be re-taught. Off-line programming can eliminate or reduce most of these problems.

Several companies offer off-line programming capabilities today, but the technology is complex and not without its hazards.

"There is little difficulty today generating an off-line program for a robot; a number of firms offer the technology. But once you have the program, problems develop," explained Mr. Weisel of Prab. "The

problem is not so much transmitting the program to the robot. You can do that with simple interfaces and a post processor that takes data generated from a CAD system and massages it into machine language. The real problem is that people make sloppy robots.

A sloppy robot may go were it is supposed to go, or it may not. If it goes where it is supposed to go today, it probably won't next week. Also, with sloppy robots, a program developed for one, would almost never run the same on another robot from the same manufacturer.

"In order to supply robot systems, we realized that robots with tight robot-to-robot tolerance were needed," said Mr. Weisel. "Prab couldn't make them so we bought them from a West German firm. But we decided that buying the technology was not enough."

Prab, therefore, bought the license from the West German firm to manufacture the robots and is starting up production.

Of the many robots systems now appearing in the U.S., an increasing number are coming from foreign firms or U.S. firms with foreign connections. Ever since the successful partnership of General Motors and Fanuc to form GMF, other U.S. firms increasingly are aligning themselves with foreign companies.

In March, Cincinnati Milacron, Inc., and Hitachi America, Ltd., a subsidiary of Hitachi Ltd., Japan, worked out such an agreement. Hichachi will supply the U.S. firm with a small industrial robot arm incorporating Cincinnati's specifications. Using controls and software supplied by Cincinnati, the new robot broadens Cincinnati's line of process robots for arc welding, sealant applications, and other uses.

Rather than linking up with U.S. firms, some foreign companies have set up their own plants in the U.S. to build robotic systems for the American market. ASEA Robotics, for example, makes robots in New Berlin, Wisc. And ESAB North America Inc., a subsidiary of ESAB AB of Sweden, primarily a welding company, makes robots for welding systems in Fort Collins, Colo. ESAB and ASEA have ties between them; ASEA owns nearly half of ESAB stock. In designing welding systems for large lot sizes, ESAB incorporates ASEA robots. But for systems calling for smaller runs, ESAB has developed its own.

Although it is a complete welding cell, ESAB concentrated on low costs and ease of use.

"For the system we developed the MAC (Mechanism Arc Center) which is a large robot that is programmed by using a lead-through teaching technique," explained John Farrell, vice president of ESAB's Robotic Welding Division. "Instead of sitting with a teach pendant or off-line programming system, you just move the weld gun, which is mounted on a robot, over the surface to be welded and just push a button where a weld is required. Since the robot is so easy to program, entering information like weld schedules is easy. The objective was to design a robot able to be programmed in a short time (10-20 pct of the automatic cycle time)."

Even without U.S. connections, foreign systems suppliers are receiving increasing numbers of orders from U.S. firms.

General Motors, for example, is paying reportedly $3 million for what may be the world's first simultaneous 5-axis, CNC carbon dioxide laser spatial robotic welding system for on-line automotive component production. The unit is being installed in GM's Linden plant, N.J. The supplier is Prima Industries S.p.A of Turin, Italy. Prima had to compete with Comau, Ferranti, and Cincinnati Milacron for the order.

Machine Vision

Another technology helping bring about robot integration is machine vision. While there is no disagreement about the potential of vision to improve factory productivity, there are doubts about the value of linking a robot with a vision system.

"I think you are going to see a lot of vision in the factory, but I think you are going to see very little of it with robots," stated Mr. Weisel. "The problem is you have vision companies that build stand-alone vision systems, and you have robot companies that build stand-alone robots. So you have an $80,000 robot trying to talk to a $40,000 to $100,000 vision system."

According to Mr. Weisel, the combination is too costly—unless that aspect of vision technology that is important to the robot is culled out and integrated with a robot in an inexpensive package.

If cost is the major obstacle, the price of vision in some cases is dropping dramatically. One vision system, soon to be introduced, will have a $25,000 price tag, less than half the price of last year's system.

"For vision to proliferate in robots it must be made cheaper," said Stanley N. Lapidus, president, Itran Corp., Manchester, N.H. "However, I believe that robots will undergo explosive growth when robust vision is built into them, but it has to be a fraction of the robot's price or you price yourself out of business."

As uses for robots become more systems-directed and more sophisticated, the need for intelligent robots becomes more critical. Robots with artificial intelligence, with the ability to respond to a wide variety of sensory cues and learn from experience, represent the future.

Vision and tactile sensing allow the robot to learn something about its environment. Decision-making enables the robot to determine its next action based on information it receives from its own senses, another machine, or an operator.

Robots that combine extensive communications ability (the ability to interact with other equipment) with repeatability, accuracy, and intelligence are the most advanced robots today—and they are rare.

Certainly, now is a period of transition from the stand-alone robot to integrated factory automation. Robot cells and systems are growing increasingly popular and the robot manufacturers are moving beyond robot production and sales into those technologies that will make the robot an integral part of the automated factory. □

PRICE & PRODUCTION DATA

(Effective March 31 1986)

Steel production by districts: thousands of tons (000 omitted)

	Last Week	Two Weeks Ago	Month Ago	Year Ago
Northeast Coast	172	186	202	170
Pittsburgh	237	246	251	252
Youngstown	114	113	113	113
Lake Erie	157	150	163	150
Detroit	142	148	150	151
Chicago	519	498	521	543
Midwest	173	172	152	192
Southern	201	192	224	207
Western	84	81	92	100
U.S. Production	1,798	1,786	1,868	1,878

Lake Superior Ore Prices

Pellets (per ton unit natural)	gross ton $60.00*
Pellets (per ton unit natural)	gross ton $59.40**
Pellets (per ton unit natural)	gross ton $72.5 56.9***
Mesabi, regular-unscreened	gross ton $32.53
Mesabi, non-bessemer	gross ton $30.03 31.53

STEEL PRODUCTION, COMPOSITE PRICES

(Effective March 31 1986)

U.S. Steel Production	Last Week	Two Weeks Ago	To Date 1986	To Date 1985
Net tons, in thousands	1,798	1,786	22,307	21,056
Capability Utilization Rate	72.1	71.6	71.1	64.7

Composite Prices	This Week	Week Ago	Month Ago	Year Ago
Finished Steel Base* (¢/lb.—eff. 1/1/86)	24.607	24.607	24.607	27.582
Pig Iron** (Net ton = 2000 lbs.)	$213.00	$213.00	$213.00	$213.00
Scrap No. 1 hvy.*** (Gross ton = 2240 lbs.)	$ 73.83	$ 73.50	$ 73.50	$ 81.83
No. 2 bundles	$ 54.50	$ 53.83	$ 52.83	$ 56.83

Scrap Comparison (Gross Ton)

No. 1 steel, Pittsburgh	$ 73.50	$ 73.50	$ 73.50	$ 83.50
No. 1 steel, Philadelphia	73.50	72.50	72.50	81.50
No. 1 steel, Chicago	74.50	74.50	74.50	80.50
No. 1 bundles, Detroit	62.50	65.50	65.50	76.50
Low Phos., Youngstown	73.50	73.50	73.50	73.50
No. 1 mach'y cast, Pgh.	73.50	73.50	73.50	71.50
No. 1 mach'y cast, Phila.	93.50	93.50	93.50	98.50
No. 1 mach'y cast, Chi.	109.50	109.50	109.50	111.50

NONFERROUS PRICES

Primary Metal Prices

Straits Tin Price

Scrap Prices
Brass Mill Scrap

	Solids	Turnings
Copper	55	53
Yellow brass	50	48
Red brass	50	47
Commercial bronze	52	51
Manganese bronze	45	44
Leaded tin bronze	50	49

Custom Smelters Scrap

No. 1 copper wire	52
No. 2 copper wire	48
Light copper	45

Ingot Makers Scrap

No. 1 copper wire	56
No. 2 copper wire	50
Light copper	47
No. 1 composition	47
No. 1 comp. turnings	46
Hvy. yellow brass solids	31
Hvy. yellow brass turnings	27
Radiators	35

Dealers' Scrap

Aluminum

Segregated clippings	31	— 33
Mixed cast clips	27	— 28
Old sheets and clips	24	— 25
Borings and turnings	21	— 22
Dirty/painted clippings	25	— 26

Copper and Brass

No. 1 copper wire	49	— 50
No. 2 copper wire	40	— 41
Light copper	33	— 34
Radiators	31	— 32
No. 1 composition	39	— 41
No. 1 composition turnings	36	— 37
Clean auto radiators	29	— 30
Clean heavy yellow brass	27	— 28
Brass pipe	28	— 29
New soft cocks & stamps	39	— 40

Lead

Heavy soft lead	5	7
Wheel balances	1	3
Type lead	15	— 17
Electrotype	13	— 14

Nickel

Nickel anode	110	—120
Nickel cut ends	110	—120
Nickel plating clips	110	—120
Nickel turnings	25	35

Zinc

New zinc clippings	15	— 16
Old diecast pic	11	— 12

EFFECTIVE MARCH 31, 1986

Ferrous Scrap Prices

Pittsburgh

Chicago

Philadelphia

Detroit

Youngstown

Cleveland

Buffalo

St. Louis

Birmingham

Cincinnati

New York

Boston

San Francisco

Los Angeles

Seattle

Hamilton, Ont.

Houston

Four changes have been made in products listed on the table. The new product listings are Oil and Gas Field Machinery, Mining Machinery & Equipment, Foundry & Forge Shop Products and Internal Combustion Engines. These replace the previously-listed Industrial Process Furnace & Ovens, Fluid Power Equipment, Cutting Tools & Accessories and Miscellaneous Metal Products. The changes are due to changes in reports by the U.S. Labor Dept.

NOW, THE QUESTION IS, WHERE'S THE BOTTOM?

In February, for the fifth time in the last nine months, producer prices fell. Prices not only declined, but the size of the drop was the largest since the U.S. Labor Dept. started calculating its price index in 1947.

Collapsing oil prices led in the price drop during the month. But prices were down across a broad front. Prices of metalworking products on the accompanying table were right in line with the price-softness trend. The average came out to zero price change.

As of February, the Labor Dept.'s over-the-year price index for all finished goods was down 0.1 pct. During the same period, prices of finished energy goods fell by 8 pct. These goods remain under considerable downside price pressures.

Prices of capital equipment were about the only increases in February. This rise, a modest 0.1 pct, came about when price increases for printing trades machinery, food products equipment and service industry machinery more than offset lower prices for trucks.

Since the double-digit price-rise days of 1979-80, some economists have said that if inflation could be brought under control, the economy would break loose in a great wave of prosperity.

Now, with prices actually disinflating, the economy is still not showing any signs of runaway growth. Growth last year came to a substandard 2.2 pct—when producer prices rose by less than 2 pct. Some industries haven't even shared in the modest economic growth that has occurred.

The explanation is apparent to many companies in basic goods lines. Imports have skimmed the cream in many markets. At the same time, the foreign competition has put on a tight lid that is now holding down prices.

Latest Month Covered: February 1986

Products	Index Reading For Month (1967 = 100)	Pct Change From Previous Month	Pct Change From Year-Ago Month
Metal Cutting Machine Tools	397.0	0	+ 1.6
Metal Forming Machine Tools	438.3	0	+ 1.6
Agricultural Machinery & Equip.	338.1	— 0.1	— 0.1
Construction Machinery & Equip.	365.4	+ 0.1	+ 0.6
Oil and Gas Field Machinery	424.1	— 0.2	— 0.8
Industrial Material Handling Equip.	295.3	— 0.1	+ 0.7
Pumps, Compressors & Allied Equip.	357.2	0	+ 0.9
Mining Machinery & Equipment	382.4	0	+ 1.4
Mechanical Power Transmission Equip.	341.0	+ 0.3	+ 1.9
Automobiles	229.6	— 0.2	+ 1.1
Motor Trucks—Light	306.0	— 0.8	+ 3.3
Motor Trucks—Heavy	340.2	— 1.4	+ 2.1
Railroad Equipment	364.9	+ 0.1	+ 0.9
Fabricated Metal Structural Products	315.8	+ 0.2	+ 0.7
Electric Motors	349.6	0	— 0.1
Valves & Fittings (Dec. 1982 = 100)	106.2	+ 0.1	+ 2.1
Ball & Roller Bearings	353.5	0	+ 2.2
Foundry & Forge Shop Products	365.2	+ 0.4	+ 0.7
Heating Equipment	264.9	+ 0.1	+ 3.0
Plumbing Fixtures & Brass Fittings	316.0	+ 0.4	+ 3.0
Metal Containers	361.2	0	+ 0.9
Internal Combustion Engines	348.9	+ 0.2	+ 2.7

Data based on U.S. Labor Dept.'s Producer Price Index